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CMS Pixel Data Quality Monitoring

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Abstract

We present the CMS Pixel Data Quality Monitoring (DQM) system. The concept and architecture are discussed. The monitored quantities are introduced, and the methods on how to ensure that the detector takes high quality data with large efficiency are explained. Finally we describe the automated data certification scheme, which is used to certify and classify the data from the Pixel detector for physics analyses.

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1. Introduction

The DQM [1] is the main tool in CMS [2] to ensure high quality data taking. It needs to be robust, reliable, and fast. It is centralized across sub-systems (sub-detectors, trigger, and physics analysis objects), and is implemented in the CMS software framework (CMSSW) [3]. The DQM is performed by automatically evaluating histograms, which are filled with information from raw as well as reconstructed data. It runs both online in real time on a fraction of events during data taking, and offline on the full statistics, but reduced granularity, using final calibration and alignment constants.

2. DQM architecture

A set of C++ programs is running on various levels of data reconstruction to fill histograms with monitoring quantities for different detector granularities. In case of the online system running in the CMS control room, the DQM applications receive a fraction of the live data stream at a configurable rate of up 25 Hz. The incoming data can be further selected using High Level Trigger bits [4]. In the case of the offline DQM, the applications are included in the same process as the data reprocessing, where they run on the full statistics, but due to computing limitations use only a reduced detector granularity. In both cases the DQM applications save the histograms and other results in centrally archived root files, which can then be browsed using the central web based CMS DQM GUI [5]. In addition to the central GUI, the Pixel experts use a versatile custom made GUI that can interact with the Pixel DQM process. This is very useful for fast problem investigations during data taking. In particular, the creation of so-called TrackerMaps, which are one page overview plots that show the status of the entire Pixel detector, and which are interactive SVG [6] maps, that can be used to pin-point problems within minutes, are of great advantage.

3. Monitored quantities

We are monitoring the following quantities to assess the Pixel data: data corruption during raw data unpacking and errors in the frontend readout electronics; raw charge from individual pixels, so-called digis; charge, size and occupancy of gain calibrated clusters as well as those of Lorentz-drift and impact angle corrected reconstructed hits; and finally we monitor clusters that are on or off reconstructed tracks.

In order to ensure that the detector is in good condition to take high quality data with high efficiency, mainly the error and digi monitoring proof to be important, since they give immediate feedback about mis-configuration, data corruption and pixel-by-pixel response to injected charge, as well as allow instant detection of noisy pixels, pixels that fire at a much higher rate than the average, which can subsequently be masked for future data taking; this has been demonstrated during the cosmic ray data taking in Fall 2008.

Instead in the offline system the majority of the feedback for reconstruction algorithms and the state of calibration and alignment is coming from the monitoring of cluster, both on and off track, as well as reconstructed hits. In addition the larger statistics compared to the online system allow to detect smaller scale detector problems.

4. Trend monitoring

In addition to monitoring the detector over the course of a single data taking run, which can last from a few minutes to one day or longer, we also extract the most important quantities for every run, store them in a database and fill them into trend plots to monitor the behaviour of the detector over large periods of time, up to many months. We do this both on a coarse granularity, e.g. for every layer of the Barrel detector, or for each ring of the Endcaps, as well as on a module by module basis if needed.

4. Data certification

In order to verify the Pixel detector data for subsequent physics analyses, we have put in place an automated scheme of statistical tests, comparison to reference plots, and the application of cuts to some of the key distributions in the offline DQM system. This has been tested for the past cosmic ray data taking and will be re-tuned for collision data. The results of this certification, a good run flag each for the Barrel and the Endcap Pixel detectors, are stored on a run-by-run, and eventually on an even finer granularity, basis in a database, where it will be available for every physics analysis in CMS.

5. Summary

The CMS Pixel DQM system has been developed to ensure high quality data taking at a high efficiency. It gives prompt feedback to detector experts as well as calibration and reconstruction procedures. It is a highly automated process that is in need of minimal human interaction when everything goes smoothly, but that is versatile enough for fast expert investigations when problems arise. It has been proven to be working very well during cosmic ray data taking in 2008, and is ready for collision data later this year.

References

[1] L.Tuura et al., *CMS data quality monitoring : systems and experiences*, Proceedings CHEP09, Prague, Czech Republic

[2] CMS Collaboration, *The CMS Experiment at the CERN LHC*, JINST 3-S8004-2008

[3] CMS Collaboration, *CMS Physics Technical Design Report Volume I, Detector Performance and Software*, CERN/LHCC/2006-001, CMS TDR 8.1, 2 February 2006

[4] CMS Collaboration, *The Trigger and Data Acquisition project, Volume II*, CERN/LHCC/2002-26, CMS TDR 6.2, 15 December 2002

[5] L. Tuura et al., *CMS data quality monitoring web service*, Proceedings CHEP09, Prague, Czech Republic

[6] Adobe®, *Basic SVG*, http://www.adobe.com/svg/basics/intro.html